

## Project Summary

**Organization Title:** Acadia Partners for Science and Learning

**Principal Investigators:**

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**Area of Interest:** Exemplary Programs

**Project Title:** *Acadia B-WET: a partnership to help teachers engage students in sustained, project-oriented investigations of the American eel (*Anguilla rostrata*) in Gulf of Maine watersheds*

**Project Duration:** 36 months (July, 2010 –June, 2013) with intention to continue beyond the first year.

**Summary of Work:** This project uses citizen science (CS) research in Gulf of Maine coastal watersheds to provide students in grades 6-12 with an understanding of the interconnectedness of coastal watershed ecosystems by engaging them in authentic scientific inquiry into the relationship between American eel (*Anguilla rostrata*) population and habitat use. Professional development (PD) will assist teachers with the scientific and pedagogical demands of this work. It builds on the project team's past experience in providing MWEE based on research at Acadia National Park. Place-based student research coupled with NOAA's online resources and a Web-based, geo-referenced database supports investigation and understanding of watersheds at different geographic scales.

**Primary Objectives:** Year 1: Develop, deliver and test curriculum materials and PD with 10 teachers; implement CS research with approximately 500 students; publish student findings. Year 2: Assess student data quality; refine field protocols; refine PD and curriculum materials; deliver and test PD with 10 additional teachers; implement CS research with approximately 1,000 students. Year 3: While continuing program improvement, initiate outreach to engage 35 teachers and approximately 1,750 students to create sustainable, ongoing programs in at least six school districts, including districts associated with other National Parks in the Northeast.

**Budget Information:**

	2010-11	2011-12	2012-13	Total
<b>federal funding requested</b>	\$ 71,692	\$ 93,878	\$ 95,696	\$ 261,266
<b>cost-sharing</b>	27,236	21,689	26,564	75,489
<b>total</b>	\$ 98,928	\$ 115,567	\$ 122,260	\$ 336,755
<b>cost/student</b>	\$ 99	\$ 58	\$ 35	\$ 52
<b>cost/teacher</b>	\$ 4,946	\$ 2,889	\$ 1,747	\$ 4,811

## **Project Description**

The proposed work is a three-year program combining Teacher Professional Development (PD) with long-term classroom-integrated Meaningful Watershed Educational Experiences (MWEE) for students. The program is based on three years of successful work with teachers and high school students who are studying watersheds in an inquiry-based framework that uses a study of mercury in foodwebs as the research focus. The proposed work will (1) extend this work to middle school students and (2) develop a new research focus on the relationship between American eels (*Anguilla rostrata*) and their habitat. The goal is to create a sustainable field research program in at least six school districts that provides MWEE across a range of grades.

More specifically, the project will involve teachers and students in studying how watershed characteristics on regional scales (for example, human development, removal of downstream dams) and local scales (water chemistry, stream size, stream habitat, culverts and other obstructions) affect the population density and distribution of eels of different sizes and ages. The project will: (1) provide teachers with the content knowledge, curriculum materials, protocols, and other materials required to support student engagement in the research and to integrate the research into the broader science curriculum; (2) provide students with an understanding of the dynamics of coastal watershed systems through a study of the role of eels in the watershed and of ecological relationships, physical and chemical requirements, and human dimensions that affect eels over their lifecycle; and (3) provide National Park Service (NPS), state agencies, and researchers with data that can support resource management and new research.

## **Project Background**

Over the past three years Acadia Partners for Science and Learning (Acadia Partners), a non-profit organization that supports and manages the NPS's Schoodic Education and Research Center (SERC) at Acadia National Park, has collaborated with the University of Maine's Senator George J. Mitchell Center for Environmental and Watershed Research (Mitchell Center) on projects that engage students and teachers in authentic scientific research. This work has been supported in part by a grant from the Maine Department of Education (MDOE) and has resulted in scientific reports and papers (Nelson et al., 2007), curriculum materials (a sample is included as an attachment), and papers describing the use of citizen science (CS) in educational settings (Zoellick et al., 2009). The research to date has focused on quantifying mercury burdens in indicator species in watersheds with different physical and chemical characteristics in order to extend the understanding developed through more than two decades of research into mercury biogeochemistry at Acadia National Park (Kahl et al., 2007).

Over the course of this work a number of core program elements have emerged:

**(1) Focus on professional development for teachers, including both content knowledge and pedagogy.** Sustainable programs must build on teacher engagement rather than running around the teacher to work directly with students.

**(2) Engagement in the practices of professional scientists.** Our program involves students in literature review, hypothesis formulation, research design, data collection, data analysis, and presentation of findings.

**(3) Full integration into the science curriculum.** Because this work involves much more than data collection, it requires significant time during the school year and must be integrated with curriculum programs and objectives.

**(4) Emphasis on truly useful results.** Data collected by students must be useful outside the school setting. Much of the engagement by students and teachers is motivated by the opportunity to provide useful service.

**(5) Participation of working scientists.** Access to working scientists is not only important to support teachers, but also helps students understand that the work is useful and reinforces use of the practices of professional science.

**(6) Sharing of data, hypotheses, and results across a region.** We are developing a geo-referenced database that allows students and teachers to post and share results. The data will also be available to scientists and managers.

### **Pilot Work for Proposed Project**

Using seed funding from NOAA during the 2009-10 school year, we have initiated pilot work with teachers in two school districts to develop techniques and materials to study eels in different ecosystems and at different life stages. We initiated this work because (1) eel populations have declined since the 1970s due to habitat loss and over-exploitation (Gulf of Maine Council on the Marine Environment, 2007) and Maine is the only state that still has a significant glass eel fishery (Shepherd, 2006); (2) Acadia National Park has an incomplete understanding of eel population density and size in smaller streams; (3) eels are a major component of fish biomass in Maine's rivers and estuaries and are therefore key elements in food webs (Thompson et al., 2005); (4) eels are long-lived and therefore "have been characterized as indicator species for bioaccumulation studies" (van der Oost et al., 1988); and (5) eels are good models for studies on evolution, life history strategies, genetics, migration, and anthropogenic effects (Maes et al., 2009). Thus, they provide a rich foundation for a variety of science programs in schools.

### **Design of Proposed Project – Eel Research Program**

Citizen science research is complicated by the need to develop research designs that support scientific research while also supporting education (Trumbull et al., 2005). We have found that it is useful to distinguish between the research questions of interest to professional scientists and the questions that are appropriate for student research.

In this project students will gather data about eels using elver ladders, eel pots, minnow traps, fyke nets, and electro-fishing. The appropriate collection mechanism will depend on the nature of the stream, its location in the watershed, presence of protected species such as Atlantic salmon, the students' grade level, and the time of year. Students will gather data on eel presence/absence, size, life cycle stage, and population density, with collection parameters dependent on the collection method. They will gather data about physical and biological stream habitat and will also make use of water quality data available from the NPS Inventory and Monitoring network (when research is in an NPS unit), from NOAA, and from other sources. Some examples of student research questions are: (1) Which collecting method (electro-fishing, settlement mats, baited eel traps, elver ladders) provides the most complete data on eel abundance and sizes in small streams of varying gradient? (2) What types of habitats (bottom type, vegetation, brush, undercut banks, shading, current speed, etc.) do eels use most in small streams?

The data collected by the students is valuable to research scientists and managers as baseline data about eel presence/absence in locations and at times of year for which no data are currently available. Questions of interest to Acadia National Park and to Dr. James McCleave, the research scientist working with this project, include (1) What are the population densities of eels, by size class, in various small-stream habitats? (2) What are the population densities, by size class, from lower to higher parts of small catchments, with evaluation of possible barriers to migration? (3) Are eels able to pass potential barriers as first-year juveniles on their initial upstream migration?

Pilot work and initial proposed work will include studies of the Penobscot River watershed, the Union River watershed, and estuaries in and around Acadia National Park. We have developed partnerships with schools and non-profit groups to expand the work to include the Androscoggin and Casco Bay watersheds in Maine and the Saugus River watershed in Massachusetts. We will include additional watersheds as we develop new partnerships.

## **Design of Proposed Project – Education Program Objectives**

**1. Design and implementing professional development programs** that will enable teachers to engage students in useful research while providing MWEE. Student learning increases when PD focuses on specific subject content as well as on pedagogical content and spans periods of six months or more (Blank & de las Alas, 2009; Suppovitz & Turner, 2000). In this program, PD consists of (1) summer institutes introducing estuarine watershed systems and the lifecycle and ecology of eels; (2) fieldwork to introduce sampling and observation protocols; (3) introduction to educational resources from the National Ocean Service (NOS) and National Estuarine Research Reserve System (NERRS) (NOAA, 2008, 2008a); (4) workshops on use of NERRS real-time data in conjunction with student data

(Parsons, 2006); and (5) workshops on analyzing and presenting data. Building on the summer experience, we support teachers in the classroom over the course of one or more school years. Teachers have ongoing access to scientific expertise and to the experiences of other teachers on a website reserved for teacher discussions.

**2. Develop web-based curriculum materials** for both teachers and students to support the research and the MWEE.

We currently use resource materials from NOS and NERRS (e.g., *Estuaries 101* and NERRS data) to introduce estuarine ecosystem concepts and to familiarize students with basic relationships such as the changes in salinity at different points in an estuary. We will develop resources that provide more information about eels and their role in the estuarine ecosystem and will make these resources available on the Web.

Our projects involve students in formulation of research questions, design of experiments, and presentation of results. In terms of the hierarchy used in the NOAA Ocean Data Education project, we engage students in many Level 5 activities (Joyce & Viola, 2009). This differentiates our work from other projects that focus on monitoring, rather than research, or focus solely on use of data from the Web, rather than student-generated data in combination with Web data. Because our watershed curricula are used in conjunction with earth science, biology, ecology, environmental science, and chemistry coursework, we develop programs to support a variety of subject matter contexts. In all cases, the program engages students in acquiring basic knowledge about watersheds, generating and evaluating scientific evidence, and participating productively in scientific practice and discourse.

**3. Enable sharing of data, hypotheses, and analysis over the Internet** through use of a common, geo-referenced database. The project will make substantial use of online data resources available through sites such as [www.dataintheclassroom.org](http://www.dataintheclassroom.org) and NERRS. However, since teachers and students are also involved in generating data, we will also create a website to enable project participants to share data across sites and with other programs. This site will build on work that is already in place in the Gulf of Maine KnowledgeBase ([gulfofmaine.org/kb/](http://gulfofmaine.org/kb/)). We will fund this work through private funding as an addition to federal support.

**4. Expand the program** to teachers and students in schools in different watershed systems contributing to the Gulf of Maine. Implementation will begin during the summer of 2010 when we will provide PD for at least 10 teachers to enable them to use estuarine and inland watershed studies of eel habitat and population as part of the school science curriculum. Teachers will be selected to ensure involvement of at least 6 schools. In the summer of 2011 we will expand the program to 20 teachers in at least a dozen schools with a goal of identifying and addressing difficulties revealed by expansion. We will include teachers who have not participated in such programs in the past, since

support and incentives for early adopter teachers is often different than for other teachers (Songer et. al, 2003), and our goal is to move beyond early adopters. In the spring of 2012 we will review our work with teachers and schools in the program and select up to six school districts in which we will seek district-wide program adoption. We will move beyond Maine, working with other NPS units such as Saugus Ironworks Historical Park (a park outside of Boston interested in eel migration and habitat) to engage school districts across more Gulf of Maine watersheds.

### Meaningful Watershed Educational Experience Support

The proposed work is a Meaningful Watershed Educational Experience in the following ways:

**Experiences are investigative or project oriented.** The entire proposed program is built around engaging students in investigations that involve both student hypotheses and contribution to a broader research effort.

**Experiences are an integral part of the instructional program.** These research projects require substantial time; they are not simply a field trip. Teachers will implement them as integral elements within biology, ecology, environmental science, and chemistry classes. They are already doing so in the current, pilot phase.

**Experiences are part of a sustained activity.** The project involves students in *preparation* in the form of background research and formulation of research questions, *action* in the form of observation of eel habitat and data collection; and *reflection* in the form of data analysis, evaluation, discussion, and presentation of findings.

**Experiences consider the watershed as a system.** Students will look at eel size and population in the context of physical and chemical watershed habitat. Such work requires thinking in terms of system dynamics.

**Experiences are place-based.** Our projects enable teachers to have students look at systems in their own backyard—near their school or in their town/watershed. Bringing science and research home to a student's own geographical area has been a key factor in student and teacher ownership of projects (Parsons, 2006). Further, students draw on their own experiences in formulating research questions and interpreting data.

**Experiences are enhanced by NOAA products, services, or personnel.** NOAA curriculum materials and data are integral parts of the project curriculum. Maine Sea Grant personnel are integral to project implementation.

The project will provide MWEE to **underserved, rural schools**. For example RSU 19, a school district included in the pilot program and the proposed project (see attached letter), is comprised of Dixmont and Newport, where, respectively, 29.6% and 23.2% of families have income below the poverty line.

## Connection to Standards

Research into use of citizen science in schools has shown that the ability to achieve higher level learning outcomes beyond mere engagement in data collection depends on addressing those higher level outcomes directly. (Trumbull et al., 2005). The proposed work provides PD and curriculum support tying the project to learning objectives identified in the Maine Learning Results (MDOE, 2007) and national standards (NRC, 1996). Specifically, the proposed work supports standards A (systems and models), B (the practice of science), and C (the nature of scientific knowledge) of the Maine Learning Results. We have attached a sample of the teacher support material from our current project to illustrate the support and linking to standards that we will provide.

## Organizations and Personnel

**Acadia Partners**, the lead organization in this collaborative effort, is a non-profit organization that manages and develops educational programs at the NPS's Schoodic Education and Research Center (SERC) at Acadia National Park. **Maine Sea Grant**, like Acadia Partners, has recognized the importance of improving the integration of CS with formal science education. Its 2006-10 strategic plan specifically identified the need "to build systems that will enable more contact with students and teachers and to formulate program content so that it fits into curricula in ways that conform to national and state learning standards, while exposing students to the many exciting themes that are represented in our coastal communities." (Maine Sea Grant, 2006: 16). The **Mitchell Center** at the University of Maine has been a key partner in Acadia Partners' development of CS programs that engage teachers and students in authentic research. It is also playing a lead role in developing Internet-based resources for storing and sharing data collected across different projects (Mitchell Center, 2009).

Key personnel include **Bill Zoellick**, Program Development Director at Acadia Partners, who will serve as Co-PI. Mr. Zoellick received an M.A.ed. degree from the University of Illinois where he studied curriculum evaluation with Dr. Robert E. Stake at the Center for Instructional Research and Curriculum Evaluation. He will be responsible for overall project coordination and administration and will contribute to the program's assessment and evaluation work.

**Beth Bisson**, Education Coordinator at the Maine Sea Grant College Program, will serve as Co-PI. At Maine Sea Grant she works with the Marine Extension Team and education partners to develop and implement formal and informal K-12 education programs aligned with the NOAA Education Goals, National Sea Grant cross-cutting priorities, and state and national education standards. Previously, she worked as a Dean John A. Knauss

Marine Policy Fellow in the NOAA Estuarine Reserves Division. Ms. Bisson holds a Master's degree in Environmental Management from the Yale School of Forestry and Environmental Studies.

**Dr. Sarah J. Nelson**, Assistant Research Professor at the Mitchell Center at the University of Maine, will serve as Co-PI. A Canon National Parks Science Scholar and professional geochemist responsible for data quality assurance for several federally-funded projects, she is a veteran of a several CS projects that connect teachers and schools. She has led intensive field research courses for students and teachers and is skilled at scientific communication to a variety of audiences.

**Dr. James D. McCleave** is Professor Emeritus at the University of Maine School of Marine Sciences and a world-renowned authority on eels. He also served as the Maine Sea Grant Associate Director for Research until September 2008. He will serve as project consultant to provide both educational and technical support for our studies of American eels. (See the attached letter.)

## **Partnerships**

The **Maine Department of Inland Fisheries and Wildlife (IF&W)** and the **Maine Department of Marine Resources (DMR)** are interested in obtaining data on eel populations so that they can better manage the fishery. They will provide technical assistance. Relevant data from this project will be included in the state's database.

**Regional School Unit 19** (Formerly MSAD 48) is now in its third year of work with Acadia Partners and the Mitchell Center focused on implementing inquiry-based learning through field experiences and is part of the eel study pilot work. **Regional School Unit 34** is another partner in the prototype project and partnered with us this past year in our program to involve students in mercury research. **Regional School Unit 24** has also participated in our mercury research and is currently collaborating with Acadia Partners in a study of science learning progressions in grades 6-12. The **Maine Department of Education (MDOE)** has provided support, now in its third year, for our work in developing and delivering programs that involve students in field-based inquiry. MDOE will continue to be an active partner as we build on the work that they have helped us initiate.

The **Saugus River Watershed Council** is working with us to extend the geographic reach of the project to include schools in the Boston area.

**Acadia National Park** is Acadia Partners' key partner in operating the Schoodic Education and Research Center. Acadia NP is interested in obtaining a better understanding of eel populations in the park's small streams.



## **Outreach and Education**

External sharing of information is built into this project. Students create posters summarizing research methods and findings. They present these posters in a variety of settings, including presentations to community stakeholders and at professional meetings such as the annual Maine Water Conference. Data gathered by students will be available on the Internet for use by other schools and by subsequent classes. We will make all PD and curriculum materials available on the Web for use by other programs. We have demonstrated commitment to presenting findings to other educators and scientists through conference presentations and papers.

## **Benefits and Results Expected**

Quantitative project benefits include: (1) intensive PD for at least 10 teachers in six or more schools, providing MWEE for approximately 500 students in the first year; (2) expansion of PD to 10 more teachers, providing support to at least a dozen schools, working with approximately 1,000 students in the second year; and (3) engagement of 35 teachers and approximately 1,750 students in the third year, with a focus on adoption within school districts.

Calculations of cost per teacher and student are included on the first page of this proposal; they assume that costs are distributed equally across teacher and student outputs. The key outcome, as distinguished from outputs, will be student engagement in MWEE with an emphasis on understanding watersheds as systems. We describe assessment of this outcome below in the section on Project Evaluation.

**Sustainability:** Our past experience is that project sustainability builds on teacher engagement and integration with the enacted curriculum. Once teachers build field research into their courses, they keep using it so long as annual expenses are modest. This request is for PD and curriculum development. Once the program is established in a school, annual costs will be manageable. Moreover, Acadia Partners was created in order to raise private money to support such ongoing work. Its match against funding requested for this project is evidence of its capability.

## **Budget Justification**

The total cost of the project is \$336,755, of which \$75,489 will be donated, leaving \$261,266 to be supported through this request. We will provide \$15,152 of additional support using funds from an in-place NOAA grant.

**Personnel/Salaries:** The roles of key personnel included in the budget narrative have been described above, under “Organizations and Personnel.” The budget also includes quarter time support for an education specialist who will focus on curriculum and PD development, and half time support for a program assistant. We include a 3% per year

cost of living increase. First year salary and benefits for Maine Sea Grant are supported through an in place Acadia Partners grant from NOAA.

**Fringe Benefits:** Fringe benefits at Acadia partners are 32% for full-time staff and 8.4% for part-time staff. The Mitchell Center and Maine Sea Grant are part of the University of Maine and use its benefits rate of 48.7%.

**Travel:** Most of the travel expense is mileage reimbursement for teachers attending workshops and for staff travel for observation, interviews, and PD support. Summer workshops will take place at SERC; Acadia Partners will donate lodging. We allocated \$40 a day for meals for teachers and instructors. Mileage reimbursement is calculated at \$0.50 per mile for 2010 and adjusted by 3% for subsequent years. We assume an average round trip of 200 miles. Travel for teacher observation and support assumes 2 trips per teacher in the first year. 1.5 trips per teacher in the second year, and 1 trip per teacher in the third year as teachers gain experience and begin to support each other within a school. In addition to mileage, we allocated \$650 for airfare, \$100 for local travel, 2 nights lodging, and associated per diem (total of \$1,278) for travel to Washington for the National B-WET conference. Acadia Partners will contribute \$400 per trip for this expense. We also include transportation expense to support the field trips, allocating \$100 per teacher for the first two years and \$60 per teacher for the third year.

**Supplies:** We allocated \$100 per teacher for the first 2 years, reduced to \$60 the third year, which we will use to supply waders, nets, and other equipment needed for fieldwork. We also allocate \$200 to cover supplies for each summer teacher workshop. Finally, we include \$500 a year to cover the cost of publications, paper and ink for student poster presentations, and other costs in support of the project.

**Contractual:** Salary, benefit, and indirect cost support for the Mitchell Center and for Maine Sea Grant is through subcontracts with these entities. All of these expenses are related to personnel in support of the project. The one other contractual expense is for consulting assistance from Dr. James D. McCleave, who will provide assistance with eel research and PD for teachers for 10 days each year at a cost of \$500 per day. Dr. McCleave's deep knowledge of eels will be critically important to organizing the citizen science work related to eels as well as to helping teachers and program staff interpret the data that we collect.

**Other Expense:** We include an allowance of \$85/day for substitute teacher support while teachers are involved in field trips, assuming 1 day per year per teacher for the first two years. For the third year we assume that cooperative arrangements between teachers in a school could reduce this cost by 20% per teacher.

**Indirect costs:** All indirect costs are calculated at 25%. The difference between the normal 26.8% rate charged by the Mitchell Center and Maine Sea Grant is a contribution from the State of Maine. Acadia Partners charges indirect costs at a 30% rate; the difference between that and the 25% charged here is a donation by Acadia Partners.

**Matching Support:** The budget includes a 29% match (\$75,489) of federal support. Part of this match is forgone indirect support (\$9,110), but the largest portion (\$66,379) consists of donated time, money, and resources from Acadia Partners. This includes donated salary and benefits (\$22,779), lodging for teachers (\$6,150), stipends for teachers as they attend workshops and participate in the project during the school year (\$21,250), support for travel to Washington (\$1,200), and funds to develop the website for teachers and geo-referenced data (\$15,000).

### **Need for Government Financial Assistance**


As already noted, this project builds on an ongoing project funded by NOAA titled “APPEL RUNS: Acadia Partners Program Expansion in Learning, Research, and Understanding Natural Science.” Funds from that project (\$15,152) will support Maine Sea Grant’s participation in the initial year of the proposed work. The project also builds on three years of support for PD and curriculum development from the Maine Department of Education. Over the coming months we will be seeking renewal of that funding to support work in the 2010-11 school year, and beyond. We have also collaborated with the University of Maine to submit a proposal to the National Science Foundation, as part of the Math Science Partnership program, for work that will enable us to strengthen communities of practice within the PD programs that we offer. Our portion of that proposal requests \$445,856 over five years.

### **Project Evaluation**

Evaluation is embedded throughout the project; two-thirds of Bill Zoellick’s time (\$30,373 including donated salary and benefits) will be committed to evaluation activities. Including travel expenses for observation and stipends paid to teachers for interviews, evaluation expense comprises more than 10% of the overall budget. The evaluation strategy is “utilization focused evaluation” as described by Patton (1990). We will approach the evaluation in four stages, as shown in the following diagram. The central question informing the evaluation is whether and to what extent the program achieves MWEE objectives, with particular focus on students’ understanding of watersheds as dynamic, living systems.

**Front-end Evaluation:** This portion of the evaluation is already underway as part of the pilot work funded through an existing NOAA grant. This work has two objectives: (1) completion of an assessment of needs and constraints in enacted curricula in grades 6-12 in a number of different rural school districts in order to design appropriate

scaffolding for the inquiry project, and (2) development and testing of field protocols for the eel study. The evaluation consists of classroom observation, in-depth interviews with teachers and administrators, and case studies.

Project Start 			
<b>Pilot Year</b> Analyze scaffolding & field requirements Dev initial PD & curric.	<b>1<sup>st</sup> Project Yr</b> Initial implementation	<b>2<sup>nd</sup> Project Yr</b> Expanded implementation	<b>3<sup>rd</sup> Project Yr</b> Expansion within school districts
Front-end Evaluation	Formative Evaluation	Implementation Evaluation	Summative Evaluation

**Formative Evaluation** of initial PD, curriculum materials, and fieldwork design. Data for this evaluation will consist of classroom observation, teacher interviews, surveys, analysis of student poster presentations, and probes to assess student understanding of specific watershed concepts.

**Implementation Evaluation** to learn how and whether materials and curriculum elements are actually used. As in our past work, we will use full-day retreats with teachers to learn which materials they use and how they use them. These full day sessions with small numbers of teachers will be supplemented by interviews with others.

**Summative Evaluation** will focus on three questions: (1) To what extent has the watershed research program become an integral part of science education in participating schools? (2) To what extent has the program been adopted across different schools in a district, different teachers with a school, and across grade levels? (3) Does the program succeed in improving students' ability to think of and analyze watersheds as an interconnected system? We will collect data regarding the first two questions through interviews, case studies, and analysis of teacher lesson plans, exams, and other assessments used by teachers. We will address the third question through pre-tests and post-tests that, among other things, ask students to draw pictures and otherwise explain graphs and tables expressing relationships between watershed phenomena. The hypothesis is that students will progress from a naïve to a more detailed, complete, and accurate understanding of the physical and biological dynamics in watersheds. We will supplement data gathered through pre and post-tests with analysis of student poster presentations.

This project is part of an ongoing effort to help students think in terms of systems and use data to support their assertions. The broader purpose of the evaluation is to help us continue to improve our ability to create and support such programs.